# Aerobic Landfill Bioremediation

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## RESEARCH OBJECTIVES

The purpose of this research is to determine the critical physical, chemical and biological processes that control aerobic landfill bioremediation. Currently, landfills are managed under CFR Subtitle D and require liners at the bottom to capture leachate, and impermeable caps at the top to limit infiltration. As such, landfills are "dry tombs," i.e., anaerobic and dry, with relatively slow biodegradation of the organic fraction of the waste and significant production of methane, an important greenhouse gas. An alternative approach that has shown promise in speeding up biodegradation and eliminating methane is aerobic biostimulation of landfills. In aerobic biostimulation, air and leachate are injected into the waste, resulting in relatively fast aerobic biodegradation and associated compaction, and no methane production. Our research is directed at understanding the process of aerobic landfill bioremediation so that optimal engineering designs can be developed.

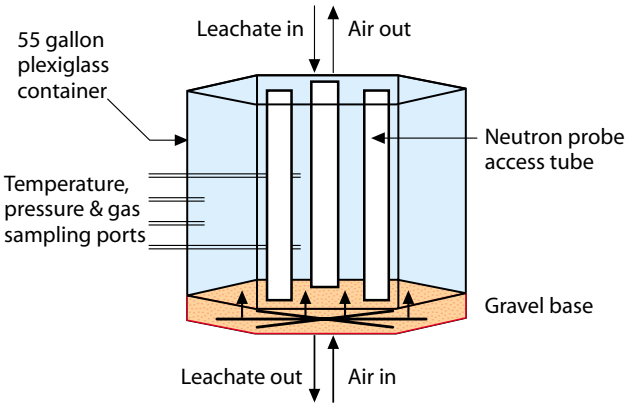


Figure 1. Schematic of laboratory lysimeter for modeling biodegradation of municipal sold waste.

## APPROACH

The complexity of landfills and landfill materials, as well as a host of practical and health-related issues, necessitates laboratory and modeling approaches as the first line of investigation as opposed to in situ landfill investigations. Our approaches to date have included literature reviews, design and construction of laboratory lysimeters and coding of biodegradation processes for numerical simulation.

## ACCOMPLISHMENTS

In the laboratory, we are preparing several 55-gallon plexiglass lysimeters for monitoring the biodegradation of a typical mixture of materials modeled after municipal solid waste, including: paper (40% by weight), food waste (12%), garden waste (10%), glass (9%), plastic (8%), metal (7%), wood (3%) and other (11%). The lysimeters will be subjected to various combinations of leachate recirculation along with air injection (see Figure 1). The lysimeters will be instrumented for temperature, moisture content and density, along with gas and leachate composition and flow rates. We will use a neutron probe for monitoring moisture content and compaction, as well as visual inspection through the clear walls of the lysimeter. Aerobic biodegradation is sensitive to air injection and leachate recirculation, the details of which will be investigated in the laboratory experiments.

On the modeling front, we are adding capabilities for modeling landfill biodegradation processes to the TOUGH2 reservoir simulator. The new module considers six components (water, acetic acid, carbon dioxide, methane, nitrogen, oxygen) and heat. The acetic acid is proxy for all biodegradable organic material. The model considers aerobic and anaerobic biodegradation depending on the local oxygen concentration. A full Monod kinetic model has been coded to simulate the biological reactions. All of the existing flow and transport capabilities of TOUGH2 will be retained in the new module. Preliminary simulations reveal that nitrogen and oxygen must be modeled separately, due to the local nature of oxygen content when aerobic processes consume oxygen and lead to relative increases in nitrogen in the gas phase.

## SIGNIFICANCE OF FINDINGS

To date our findings are limited to results of literature surveys, experiment design, and numerical experiments. Although batch models of biodegradation of landfill materials have been developed and applied, no one has modeled unsaturated flow and transport with landfill biological processes. The differing needs of batch and fully 3-D simulations require careful consideration of oxygen and nitrogen components in air for modeling aerobic biodegradation processes.

## RELATED PUBLICATIONS

Oldenburg, C.M., T.C. Hazen and S.E. Borglin, Simulation of landfill bioreactors, Berkeley Lab report, in preparation.

March, J., M. Hudgins and T.C. Hazen, Aerobic landfill bioreactor demonstration, Environ. Sci. Technol., submitted.

## ACKNOWLEDGEMENTS

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